Part V

Background Information

General Notes

Chemical Abstract Service (CAS) Registry Numbers

Chemicals are assigned unique identifying numbers, chemical abstract numbers, when they first appear in the chemical literature. Identification of a chemical by its abstract number eliminates the difficulties that can occur when one attempts to locate a chemical using a chemical name. Chemicals have multiple names and if chemical information is not catalogued under the name one is searching for, information can be missed.

To make sure that you can locate information on all chemicals, you should:

1. Obtain the chemical abstract service (CAS) registry numbers for all chemicals at the site.
2. Use the "Chemical Abstract Service (CAS) Registry Numbers" table to identify the name that chemicals are catalogued under in the tables, and
3. Search for information using the chemical names identified in step 2.

Nomenclature and Indexing

Names of organic chemicals are frequently preceded by numbers or certain letters used to describe the structure of the chemical. For purposes of indexing chemical names, this structural information is placed at the end of the chemical name. Examples follow:

Chemical Name	Chemical Name as Indexed in Tables
N,N-dimethylaniline	dimethylaniline;N,N-
p-chlorophenol	chlorophenol;p-
1,2-dichloroethane	dichloroethane;1,2-
cis-1,2-dichloroethene	dichloroethene;1,2-cis

Note that for chemical names which have the prefix "bis," the "bis" remains at the beginning of the chemical name for indexing purposes.

Notes on Standard Method B and Standard Method C Formula Values

Ground Water

The tables list the ground water concentrations that are **protective of human health** under standard Method B and standard Method C using the equations and default values provided in the regulation. See WAC 173-340-720(4)(b)(iii) and 173-340-720(5)(b)(iii). The following equations were used:

- Equation 720-1 (non-carcinogens)
- Equation 720-2 (carcinogens)

The pre-calculated values are NOT cleanup levels. The values DO NOT account for the following:

- Consideration of applicable state and federal laws;
- Consideration of surface water impacts;
- Consideration of total site risk;
- Consideration of the NAPL limitation;
- Consideration of natural background concentrations; and
- Consideration of practical quantitation limits.

Surface Water

The tables list the surface water concentrations that are **protective of human health** under standard Method B and standard Method C using the equations and default values provided in the regulation. See WAC 173-340-730(3)(b)(iii) and 173-340-730(4)(b)(iii). The following equations were used:

- Equation 730-1 (non-carcinogens)
- Equation 730-2 (carcinogens)

The pre-calculated values are NOT cleanup levels. The values DO NOT account for the following:

- Consideration of applicable state and federal laws;
- Consideration of ecological impacts;
- Consideration of total site risk;
- Consideration of the NAPL limitation;
- Consideration of natural background concentrations; and
- Consideration of practical quantitation limits.

Air

The tables list the air concentrations that are **protective of human health** under standard Method B and standard Method C using the equations and default values provided in the regulation. See WAC 173-340-750(3)(b)(ii) and 173-340-750(4)(b)(ii). The following equations were used:

- Equation 750-1 (non-carcinogens)
- Equation 750-2 (carcinogens)

The pre-calculated values are NOT cleanup levels. The values DO NOT account for the following:

- Consideration of applicable state and federal laws;
- Consideration of the lower explosive limit limitation;
- Consideration of total site risk;
- Consideration of natural background concentrations; and
- Consideration of practical quantitation limits.

Soil

The tables list the soil concentrations that are **protective of human health** under standard Method B (unrestricted land use) and standard Method C (industrial land use) for both the **direct contact pathway (ingestion only)** and the **leaching pathway** (protection of ground water).

Protective concentrations based on the **direct contact pathway (ingestion only)** were calculated using the equations and default values provided in the regulation. See WAC 173-340-740(3)(b)(iii)(B) and 173-340-745(5)(b)(iii)(B). The following equations were used:

- Equation 740-1 (Method B: non-carcinogens)
- Equation 740-2 (Method B: carcinogens)
- Equation 745-1 (Method C: non-carcinogens)
- Equation 745-2 (Method C: carcinogens)

Protective concentrations based on the **leaching pathway** were not pre-calculated. To calculate the soil concentration that is protective of ground water, use the "Workbook for Calculating Cleanup Levels for Individual Hazardous Substances" (MTCASGL10.XLS), located at http://www.ecy.wa.gov/programs/tcp/cleanup.html.

The pre-calculated soil concentrations are NOT cleanup levels. The values DO NOT account for the following:

- Consideration of applicable state and federal laws;
- Consideration of ecological impacts;

- Consideration of dermal contact as part of the direct contact pathway;
- Consideration of residual saturation for protection of ground water;
- Consideration of the vapor pathway;
- Consideration of total site risk;
- Consideration of natural background concentrations; and
- Consideration of practical quantitation limits.

NOTE: CLARC does not provide pre-calculated values for petroleum mixtures for any media. Please refer to Part IV of CLARC for more information.

Notes on Applicable State and Federal Laws (ARARs)

Potable Ground Water

The table "Potable Ground Water – ARARs and Standard Method B and C Formula Values" lists the concentrations established under applicable state and federal laws that must be considered when establishing cleanup levels for potable ground water (see WAC 173-340-720(3)(b)(ii), (4)(b)(i), and (5)(b)(i)). These concentrations are defined as "maximum contaminant levels" or "MCLs".

For hazardous substances for which sufficiently protective, health-based concentrations have been established under applicable state and federal laws, the most stringent of those concentrations is used. A concentration established under applicable state and federal laws is sufficiently protective if the excess cancer risk does not exceed 1 in 100,000 (1×10^{-5}) and the hazard quotient does not exceed one (1). If the concentration is not sufficiently protective, then either the concentration must be adjusted downward in accordance with WAC 173-340-720(7)(b) or a protective concentration must be calculated using the equations provided in the regulation.

For hazardous substances for which health-based concentrations have not been established under applicable state and federal laws, a protective concentration must be calculated using the equations provided in the regulation.

Surface Water – Protection of Human Health

The table "Surface Water – ARARs – Ambient Water Quality Criteria for Protection of Human Health" lists concentrations established under applicable state and federal laws that must be considered when establishing cleanup levels for surface water. See WAC 173-340-730(2)(b)(i), (3)(b)(i), and (4)(b)(i). These concentrations are defined as "ambient water quality criteria". The source for each of the values published in the table is listed in the table.

For hazardous substances for which sufficiently protective, health-based concentrations have been established under applicable state and federal laws, the most stringent of those concentrations is used. See WAC 173-340-730(3)(b)(iii), (4)(b)(iii). A concentration established under applicable state and federal laws is sufficiently protective if the excess cancer risk does not exceed 1 in 100,000 (1×10^{-5}) and the hazard quotient does not exceed one (1). If the concentration is not sufficiently protective, then either the concentration must be adjusted downward in accordance with WAC 173-340-730(5)(b) or a protective concentration must be calculated using the equations provided in the regulation.

For hazardous substances for which health-based concentrations have not been established under applicable state and federal laws, a protective concentration must be

calculated using the equations provided in the regulation. See WAC 173-340-730(3)(b)(iii), (4)(b)(iii).

Surface Water – Protection of the Environment

The table "Surface Water – ARARs – Ambient Water Quality Criteria for Protection of Aquatic Life" lists concentrations established under applicable state and federal laws that must be considered when establishing cleanup levels for surface water (see WAC 173-340-730(2)(b)(i), (3)(b)(i), and (4)(b)(i)). These concentrations are defined as "ambient water quality criteria". The source for each of the values published in the table is listed in the table.

For hazardous substances for which environmental effects-based concentrations have been established under applicable state and federal laws, the most stringent of those concentrations is used. See WAC 173-340-730(3)(b)(iii), (4)(b)(iii).

For hazardous substances for which environmental effects-based concentrations have <u>not</u> been established under applicable state and federal laws, a protective concentration must be established. Protective concentrations are defined as concentrations that do not result in adverse effects on the protection and propagation of fish, aquatic life and wildlife. See WAC 173-340-730(3)(b)(iii), (4)(b)(iii).

Whole effluent toxicity (WET) testing may be used to demonstrate that a concentration is protective of fish and aquatic life. Other methods may need to be used to demonstrate that a concentration is protective of wildlife, if this is a concern at the site.

Notes on Chemical-Specific Parameters – Toxicological Properties

Cancer Potency Factors – General

CLARC no longer contains the old U.S. EPA's alphanumeric classification system (A, B1, B2, C, D and E categories) for carcinogens. EPA no longer uses or recognizes the old alphanumeric classification system for carcinogens.

Note that three descriptors of human carcinogenic potential have replaced the alphanumeric classification system. As described in EPA's "Proposed Guidelines for Carcinogen Risk Assessment" (EPA/600/P-92/003C, April 1996), these three categories are as follows: (1) Known / likely; (2) Cannot be determined; and (3) Not likely. Further descriptions of each of the three categories detail a chemical's biological action.

Oral Cancer Potency Factors (CPFo)

For hazardous substances that are carcinogenic, oral cancer potency factors (CPFo) are used to calculate ground water, surface water, and soil concentrations that are protective of human health.

The source for each oral cancer potency factor is published in CLARC. Except as noted below, the values were obtained from the most recent versions of the IRIS and HEAST databases. The following table lists the chemicals for which values were not available in the IRIS or HEAST databases, but were available through other sources (EPA Region X [RX] or EPA's Environmental Criterion and Assessment Office [ECAO]).

CAS #	Chemical Name	CPFo	CPFo Reference
71-43-2	Benzene	0.055	RX0601/0601
56-55-3	Benzo[a]anthracene	7.3	RX7/92;3/93
205-99-2	Benzo[b]fluroanthene	7.3	RX7/92;3/93
207-08-9	Benzo[k]fluroanthene	7.3	RX7/92;3/93
218-01-9	Chrysene	7.3	RX7/92;NI11/00
53-70-3	Dibenzo[a,h]anthracene	7.3	RX7/92;3/93
193-39-5	Indeno[1,2,3-cd]pyrene	7.3	RX7/92;3/93
Unavailable 05	PAH	7.3	RX7/92;3/93
72-56-0	Perthane	0.00033	ECAO,12/91

See WAC 173-340-708(8).

Inhalation Cancer Potency Factor (CPFi)

For hazardous substances that are carcinogenic, inhalation cancer potency factors (CPFi) are used to calculate air concentrations that are protective of human health.

The source for each inhalation cancer potency factor (CPFi) is published in CLARC. The values were obtained from the most recent versions of the IRIS and HEAST databases. See WAC 173-340-708(8).

Oral Reference Doses (RfDo)

For hazardous substances that are non-carcinogenic, oral reference doses (RfDo) are used to calculate ground water, surface water, and soil concentrations that are protective of human health.

- **Sources:** The source for each oral reference dose is published in CLARC. Except as noted below, the values were obtained from the most recent versions of the IRIS and HEAST databases. The following table lists the chemicals for which values were not available in the IRIS or HEAST databases, but were available through other sources (EPA Region X [RX] or EPA's Environmental Criterion and Assessment Office [ECAO]).

CAS #	Chemical Name	RfDo	RfDo Reference
71-43-2	Benzene	0.003	RX0601/0601
786-19-6	Carbophenothion	0.00013	ECAO6/91;NI12/00
7440-50-8	Copper	0.037	From DWC;NI12/00
115-90-2	Fensulfothion	0.00025	ECAO6/91;NI12/00
7786-34-7	Mevinphos	0.00025	ECAO6/91;NI12/00
72-56-0	Perthane	0.003	ECAO,12/91

See WAC 173-340-708(7).

- **Toxic Effects:** The toxic effects of each hazardous are published in CLARC. The following table provides a list of the toxicity classifications and their meaning:

Classification	Meaning
Adrenal gland	Toxic effects on the adrenal gland.
Alopecia	Toxic effects on the hair, usually hair loss.
Bladder	Toxic effects on the bladder.
Cardiovascular toxicity	Toxicity to the blood vessels or heart.
Cholinesterase inhibition	Enzyme reduction or inhibition
Dermal toxicity	Toxic effects on the skin.
Developmental toxicity	Toxicity to the fetus or developing embryo.
Gastrointestinal toxicity	Toxicity to the digestive tract.
Hemotoxicity	Damage to blood, blood cells, reduction in the ability of the body to produce blood or blood components.
Hepatotoxicity	Damage to the liver or liver function.
Immunotoxicity	Toxicity to the immune system.
Mortality	Death

Nephrotoxicity:	Damage to the kidneys or kidney function.
Neurotoxicity	Damage to the nervous system.
Oculartoxicity	Damage to the eyes.
Pulmonary toxicity	Toxicity to the lungs.
Prostate	Toxic effects on the prostate.
Reproductive toxicity	Toxicity to the reproductive organs (i.e., ovaries, testes, etc.)
Spleen toxicity	Toxic effects on the spleen.
Thymus toxicity	Toxic effects on the thymus
Thyroid toxicity	Toxic effects on the thyroid.
Weight:	A broad classification of toxicity which may indicate: 1. Overall weight decrease. 2. An overall weight increase. 3. A decrease in the rate of weight gain.

- **Additive Risk:** If a site hazard index exceeds 1.0, the toxicity information included should be used to sort the chemicals present at a hazardous waste site into subgroups based on toxic effect endpoints. Hazard indices would then be calculated for each toxicity endpoint subgroup.

Inhalation Reference Doses (RfDi)

For hazardous substances that are non-carcinogenic, inhalation reference doses (RfDi) are used to calculate air concentrations that are protective of human health.

The source for each inhalation reference dose is published in CLARC. Except for benzene, the values were obtained from the most recent versions of the IRIS and HEAST databases. The value for benzene was obtained from EPA Region X. See WAC 173-340-708(7).

EPA has been tabulating inhalation reference doses in terms of:

1. Concentration (i.e., mg per cubic meter)
2. Dose (i.e., mg per kg per day)

Inhalation reference doses listed in the table are in terms of mg/kg-day. When establishing air cleanup levels, HEAST or IRIS should be checked for chemicals that do not have values listed in the table.

Concentration-based inhalation reference doses may be converted to actual doses using the following formula:

$$\text{Dose (mg/kg-day)} = \text{Concentration (mg/m}^3\text{)} \times 1/70 \text{ kg} \times 20 \text{ m}^3\text{/day}$$

Bioconcentration Factors (BCF)

Bioconcentration factors (BCF) are used to calculate surface water concentrations that are protective of human health.

The source for each bioconcentration factor (BCF) is published in CLARC. The values are those established by the U.S Environmental Protection Agency to establish ambient water quality criteria. See WAC 173-340-708(9).

Key to References for Chemical-Specific Toxicological Parameters

The references for each of the chemical-specific toxicological parameter values are listed in the tables. The references listed in the table include the source of the value, as well as historical and other relevant information. A number of abbreviations are used in noting literature references to information provided in the tables. Below is a key to these references and examples as to how they are used.

Reference	Meaning
I	"I" in a reference column means that a value was obtained from EPA's Integrated Risk Information System (IRIS).
H	"H" in a reference column means that a value was obtained from EPA's Health Effects Assessment Summary Tables (HEAST).
RX	"RX" in a reference column means that a value was obtained from EPA Region X.
ECAO	"ECAO" in a reference column means that a value was obtained from EPA's Environmental Criterion and Assessment Office.
EOTS	"EOTS" in a reference column means that data was obtained from EPA's Office of Toxic Substances.
N	"N" in a reference column means that a value was not available.
P	"P" in a reference column means that a value is pending.
R	"R" in a reference column means that a value is under review.
W	"W" in a reference column means that a value was withdrawn.

Examples:

Value	Reference	Explanation
67	ECAO6/91;12/91	This value was obtained from a memo supplied by EPA's Environmental Criterion and Assessment Office and was added to CLARC II in December of 1991.
68	EOTS4/93;4/93	This value was obtained from information supplied by EPA's Office of Toxic Substances in April of 1993 and was added to the Model Toxics Control Act Parameter Table in April of 1993.
0.01	H91a; NI12/91	This value was obtained from the Health Effects Assessment Summary Table (HEAST), 1991, first quarter. The Integrated Risk Information System (IRIS) was checked for the value in December of 1991 and was not available.

10.2	H91a; PI12/91	This value was obtained from HEAST, 1991, first quarter. IRIS was checked for the value in December of 1991 and it was noted that an IRIS value is in the process of being developed.
0.70	I3/91; 12/91	This value was obtained from IRIS. EPA added or revised information relating to this value in March of 1991. It was checked or added to CLARC II in December of 1991.
4.5	RX9/90; 12/91	This value was obtained from a memo supplied by EPA Region X's risk assessment group in September of 1990. It was checked or added to the Model Toxics Control Act Parameter Table in December of 1991.

Where no value appears opposite a reference, it means that those references were checked for a value and none were found, or that the information provided was not suitable for use, for example:

H93a;NI12/93	HEAST (1st quarter 1993) and IRIS (checked in December of 1993) did not contain any value for the parameter being searched for.

Notes on Chemical-Specific Parameters – Physical and Chemical Properties

Soil Organic Carbon-Water Partitioning Coefficient (Koc)

The soil organic carbon-water partitioning coefficient (Koc) is the ratio of the mass of a chemical that is adsorbed in the soil per unit mass of organic carbon in the soil per the equilibrium chemical concentration in solution. It is the "distribution coefficient (Kd)" normalized to total organic carbon content. Koc values are useful in predicting the mobility of organic soil contaminants; higher Koc values correlate to less mobile organic chemicals while lower Koc values correlate to more mobile organic chemicals.

This parameter is used to calculate a soil concentration that is protective of ground water using the 3-phase and 4-phase equilibrium partitioning models. The parameter is chemical-specific. Only values for organics are published in CLARC. Koc is used to derive a Kd value for organics using Equation 747-2. See WAC 173-340-747(4)(c).

References: The default Koc values published in CLARC are based on a pH of 6.8 and were obtained from the following hierarchy of sources:

Key	Source
SSG96, T.38	U.S. EPA, *Soil Screening Guidance: Technical Background Document*, EPA/540/R-95/128, May 1996, Table 38.
SSG01, T.C-1	U.S. EPA, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites,* Peer Review Draft, OSWER 9355.4-24, March 2001, Table C-1.
SSG96, T.C-1	U.S. EPA, *Soil Screening Guidance: User's Guide*, EPA/540/R-96/018, April 1996, Table C-1.
SSG01, T.C-2	U.S. EPA, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites,* Peer Review Draft, OSWER 9355.4-24, March 2001, Table C-2.
SSG94	U.S. EPA, *Technical Background Document for Draft Soil Screening Level Guidance*, EPA/540/R-94/018, March 1994.
ATSDR	ATSDR Toxicological Profile (TP 91/13)
CWG, 1997	Gustafson, J.B. et al., *Selection of Representative TPH Fractions Base on Fate and Transport Considerations, Total Petroleum Hydrocarbon Criteria Working Group Series*, Volume 3 (1997).
USGS, 1996	U.S. Geological Survey, *Final Report on Fuel Oxygenate*s, March 1996.

Distribution Coefficient (Kd)

The "distribution coefficient" (Kd) is the "soil-water" partitioning coefficient. Kd (L/kg) is the ratio of a chemical's sorbed concentration (mg/kg) to the dissolved concentration (mg/L) at equilibrium, as illustrated below:

Kd (L/kg) = Sorbed Concentration (mg/kg) / Dissolved Concentration (mg/L)

For organics, Kd may be calculated by multiplying **Koc** (the soil organic carbon-water partitioning coefficient) by **foc** (the mass fraction of soil organic carbon content), as illustrated below:

Kd = Koc x foc [Equation 747-2].

This parameter is used to calculate a soil concentration that is protective of ground water using the 3-phase and 4-phase equilibrium partitioning models. The parameter is site-specific and chemical-specific. Only values for metals are published in CLARC. See WAC 173-340-747(4)(c).

References: The default Kd values published in CLARC are based on a pH of 6.8 and were obtained from the following sources:

Key	Source
SSG01, T.C-4	U.S. EPA*, Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites,* Peer Review Draft, OSWER 9355.4-24, March 2001, Table C-4.
Baes, 1983	Baes, C.F. (III), and R.D. Sharp, *A Proposal for Estimation of Soil Leaching and Leaching Constants for use in Assessment Tools*, J. Environ. Quality, Vol. 12, No. 1, pp. 17-28, 1983.
Radian, 1990	Radian Corporation, *Evaluation of Soil Remedial Levels for Frontier Hard Chrome, Vancouver, Washington*, Draft Technical Memorandum, October 1990.
EPA, 1994	U.S. EPA, *Composite Model for Leachate Migration with Transformation Products (EPACMTP)*, April 1994.

Henry's Law Constant (Hcc)

Henry's law constant (Hcc) is the ratio of a chemical's concentration in the air to its concentration in water at equilibrium. This parameter can vary significantly with temperature for some chemicals. For the purposes of the regulation, the dimensionless form of this parameter is used.

This parameter is used to calculate a soil concentration that is protective of ground water using the 3-phase and 4-phase equilibrium partitioning models. The parameter is chemical-specific. See WAC 173-340-747(4)(d).

References: The default values published in CLARC were obtained from the following sources:

Key	Source
SSG01, T.C-1	U.S. EPA, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites,* Peer Review Draft, OSWER 9355.4-24, March 2001, Table C-1.
SSG96, T.C-1	U.S. EPA, *Soil Screening Guidance: User's Guide*, EPA/540/R-96/018, April 1996, Table C-1.
CWG, 1997	Gustafson, J.B. et al., *Selection of Representative TPH Fractions Base on Fate and Transport Considerations, Total Petroleum Hydrocarbon Criteria Working Group Series*, Volume 3 (1997).
USGS, 1996	U.S. Geological Survey, *Final Report on Fuel Oxygenate*s, March 1996.
Rule	MTCA Cleanup Regulation, WAC 173-340-747(4)(d).

Aqueous Solubility (S)

This parameter is used to calculate a soil concentration for petroleum and other mixtures that is protective of ground water using the 4-phase equilibrium partitioning model. This parameter is also used to calculate the soil saturation limit for single hazardous substances. The parameter is chemical-specific.

References: The default values published in CLARC were obtained from the following sources:

Key	Source
SSG01, T.C-1	U.S. EPA*, Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites,* Peer Review Draft, OSWER 9355.4-24, March 2001, Table C-1.
SSG96, T.C-1	U.S. EPA*, Soil Screening Guidance: User's Guide*, EPA/540/R-96/018, April 1996, Table C-1.
CWG, 1997	Gustafson, J.B. et al., *Selection of Representative TPH Fractions Base on Fate and Transport Considerations, Total Petroleum Hydrocarbon Criteria Working Group Series*, Volume 3 (1997).
USGS, 1996	U.S. Geological Survey, *Final Report on Fuel Oxygenate*s, March 1996.

Assessing the Carcinogenic Risk of Mixtures using Toxicity Equivalence Factors

Introduction

The toxicity equivalency factor (TEF) methodology was developed by the U.S. Environmental Protection Agency to estimate the hazard of a mixture of structurally related chemicals with a common mechanism of action. The TEF methodology is useful to estimate the hazards / risks of complex chemical mixtures where there is insufficient information to evaluate all of the chemicals that compose the mixture or the mixture itself. Generally, the TEF methodology is applied in situations where the chemical components of the mixture are known and the chemical composition of the mixture will not substantially change over time. This section of CLARC briefly describes the process for assessing the carcinogenic risk of mixtures using TEFs and provides the TEFs for mixtures of cPAHs and mixtures of CDDs and CDFs.

Assessing the Carcinogenic Risk of Mixtures of cPAHs

Polycyclic aromatic hydrocarbons (carcinogenic) or "cPAHs", as defined in WAC 173-340-200, means those polycyclic aromatic hydrocarbons substances, PAHs, identified as A (known human) or B (probable human) carcinogens by the United States Environmental Protection Agency. These include benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

When assessing the potential carcinogenic risk of mixtures of cPAHs under the MTCA Cleanup Regulation (WAC 173-340-708(8)(e)), one of the following two methods must be used unless the department determines that there is clear and convincing scientific data which demonstrates that the use of these methods is inappropriate:

(1) Assessment using Default Toxicity

The entire mixture is assumed to be as toxic as benzo(a)pyrene; OR

(2) Assessment using Toxicity Equivalence Factors

The toxicity equivalency factors and methodology described in the following document is used:

> CalEPA, 1994. *"Benzo(a)pyrene as a toxic air contaminant. Part B: Health Assessment,"* Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Berkeley, CA.

When using this methodology, each of the following compounds at a minimum must be analyzed for and included in the calculations:

- Benzo[a]pyrene,
- Benz[a]anthracene,
- Benzo[b]fluoranthene,
- Benzo[k]fluoranthene,
- Chrysene,
- Dibenz[a,h]anthracene, AND
- Indeno[1,2,3cd]pyrene.

The department may require additional compounds from the CalEPA list to be included in the methodology should site testing data or information from other comparable sites or waste types indicate the additional compounds are potentially present at the site.

NOTE: Many of the polycyclic aromatic hydrocarbons on the CalEPA list are found primarily in air emissions from combustion sources and may not be present in the soil or water at contaminated sites. Users should consult with the department for information on the need to test for these additional compounds.

Assessing the Carcinogenic Risk of Mixtures of CDDs and CDFs

Mixtures of chorinated dibenzo-p-dioxin (CDDs) and chlorinated dibenzofurans (CDFs) are complex mixtures of 210 interrelated chemicals composed of different CDDs and CDFs. (U.S. EPA, 1989)

When assessing the potential carcinogenic risk of mixtures of CDDs and CDFs under the MTCA Cleanup Regulation (WAC 173-340-708(8)(d)), one of the following two methods must be used unless the department determines that there is clear and convincing scientific data which demonstrates that the use of these methods is inappropriate:

(1) Assessment using Default Toxicity

The entire mixture is assumed to be as toxic as 2, 3, 7, 8 TCDD; OR

(2) Assessment using Toxicity Equivalence Factors

The toxicity equivalency factors and methodology described in the following document is used:

> U.S., EPA. 1989. *"Interim procedures for estimating risks associated with exposure to mixtures of chlorinated dibenzo-p-dioxins and dibenzofurans (CDDs and CDFs) and 1989 update,"* U.S. EPA, Risk Assessment Forum, Washington, D.C., EPA/625/ 3-89/016.

Determining Toxicity Equivalence Factors

A toxicity equivalency factor (TEF) is an estimate of the relative toxicity (by an order of magnitude) of a chemical compared to a **reference chemical**.

(1) Mixtures of cPAHs

For mixtures of cPAHs, the reference chemical is **benzo(a)pyrene**. Benzo(a)pyrene was chosen as the reference chemical because the toxicity of the chemical is well characterized. The toxicity equivalency factor for each cPAH is an estimate of the relative toxicity (by an order of magnitude) of the congener compared to benzo(a)pyrene.

Table 1: Toxicity Equivalence Factors for cPAHs

cPAH	Toxicity Equivalency Factor*
Benzo(a)pyrene**	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Chrysene	0.01
Dibenz(a,h)anthracene	0.4
Indeno(1,2,3-cd)pyrene	0.1

* Source: CalEPA, 1994. *"Benzo(a)pyrene as a toxic air contaminant. Part B: Health Assessment,"* Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Berkeley, CA.

** Reference chemical for cPAHs

(2) Mixtures of CDDs and CDFs

For mixtures of CDDs and CDFs, the reference chemical is **2,3,7,8 tetrachlorodibenzo-p-dioxin (2,3,7,8 TCDD)**. 2,3,7,8 TCDD was chosen as the reference chemical because the toxicity of the chemical is well characterized. The toxicity equivalency factor for each CDD or CDF is an estimate of the relative toxicity (by an order of magnitude) of the congener compared to 2,3,7,8 TCDD**.**

Table 2: Toxicity Equivalence Factors for CDDs and CDFs

CDD or CDF	Toxicity Equivalency Factor*
CDDs	
MonoCDDs	0
DiCDDs	0
TriCDDs	0
2,3,7,8-TCDD**	1
Other tetraCDDs	0
2,3,7,8-pentaCDD	0.5
Other pentaCDDs	0
2,3,7,8-hexaCDD	0.1
Other hexa CDDs	0
2,3,7,8-heptaCDD	0.01
Other heptaCDDs	0
OctaCDD	0.001
CDFs	
MonoCDFs	0
DiCDFs	0
TriCDFs	0
2,3,7,8-tetraCDF	0.1
Other tetraCDFs	0
1,2,3,7,8-pentaCDF	0.05
2,3,4,7,8-pentaCDF	0.5
Other pentaCDFs	0
2,3,7,8-hexaCDFs	0.1
Other hexa CDFs	0
2,3,7,8-heptaCDF	0.01
Other heptaCDFs	0
OctaCDF	0.001

* Source: U.S. EPA, 1989. *"Interim procedures for estimating risks associated with exposure to mixtures of chlorinated dibenzo-p-dioxins and dibenzofurans (CDDs and CDFs) and 1989 update,"* U.S. EPA, Risk Assessment Forum, Washington, D.C., EPA/625/ 3-89/016.

** Reference chemical for CDDs and CDFs

Determining Toxicity Equivalent Concentrations

To determine the toxicity equivalent concentration for mixtures of cPAHs, CDDs, and CDFs, the user should follow the following set of instructions:

1. Analyze the chemical mixture in a sample to determine the congeners and the concentration of each congener.

2. Multiply each congener concentration identified in the sample by the applicable toxicity equivalence factor (TEF) in the tables above to obtain a toxicity equivalent concentration (TEC).

3. Add the products in step 2 to obtain the total toxicity equivalent concentration (TTEC) for the chemical mixture.

4. Compare the total toxicity equivalent soil concentration (TTEC) for the chemical mixture with the applicable cleanup level for the reference chemical.

Example

Consider a site where the soil is contaminated with a mixture of cPAHs and assume that cleanup levels are established under Method B. The following steps should be followed to determine whether the soil concentrations exceed the cleanup level. Measured soil concentrations and calculations referred to in the following steps are presented in the table below.

Step 1: Analyze the cPAH mixture at the site to determine the congeners [column 1] and the soil concentration of each congener [column 2].

Step 2: For each congener identified at the site, multiply the soil concentration [column 2] by the applicable toxicity equivalence factor (TEF) [column 3] to obtain a toxicity equivalent soil concentration (TEC) [column 4].

Step 3: Add the products in step 2 to obtain the total toxicity equivalent soil concentration (TTEC) for the cPAH mixture [= 23.65 mg/kg].

Step 4: Compare the total toxicity equivalent soil concentration (TTEC) for the cPAH mixture [23.65 mg/kg] with the Method B cleanup level for benzo(a)pyrene [0.1 mg/kg].

The total toxicity equivalent soil concentration for the cPAH mixture [23.65 mg/kg] exceeds the Method B cleanup level for benzo(a)pyrene [0.1 mg/kg]. Therefore, the cleanup level for benzo(a)pyrene has not been met.

1	2	3	4
cPAH Congener	**Measured Soil Concentration (mg/kg)**	**Toxicity Equivalence Factor (unitless)**	**Toxicity Equivalent Soil Concentration (mg/kg)**
Benzo(a)pyrene	10	1.0	10
Benzo(a)anthracene	15	0.1	1.5
Benzo(b)fluoranthene	20	0.1	2.0
Benzo(k)fluoranthene	10	0.1	1.0
Chrysene	15	0.01	0.15
Dibenz(a,h)anthracene	20	0.4	8.0
Indeno(1,2,3-cd)pyrene	10	0.1	1.0
Total	**100**		**23.65**